Semiconductor Industry Growing Rapidly

Economic Census data show that semiconductor manufacturing is a rapidly growing industry. It is geographically concentrated, but rural areas may become more attractive to semiconductor manufacturers.

As microprocessors have been introduced into more and more products, the semiconductor manufacturing industry has grown rapidly. The Semiconductor Association of America reported worldwide semiconductor sales of over $11 billion per month in mid-1999. U.S. employment in the sector grew more than 25 percent from 1993 to 1999. Over that same period, other manufacturing industries generally posted only slight gains in employment (fig.1). Semiconductor manufacturing jobs are also highly paid, averaging $18 per hour for production workers in mid-1999, compared with an average for all manufacturing of under $14.

Drawn by the allure of the industry's growth in high-paying skilled jobs, relatively low emission of pollutants, and its "high-tech" image, economic development officials have offered expensive enticements for companies to locate semiconductor plants in their communities or States. The 1997 Economic Census provides information about growth in production, capital expenditures, employee earnings, and materials purchases for the semiconductor industry. This type of information can help local and State officials make informed decisions about industry recruitment, regional planning, and other issues.

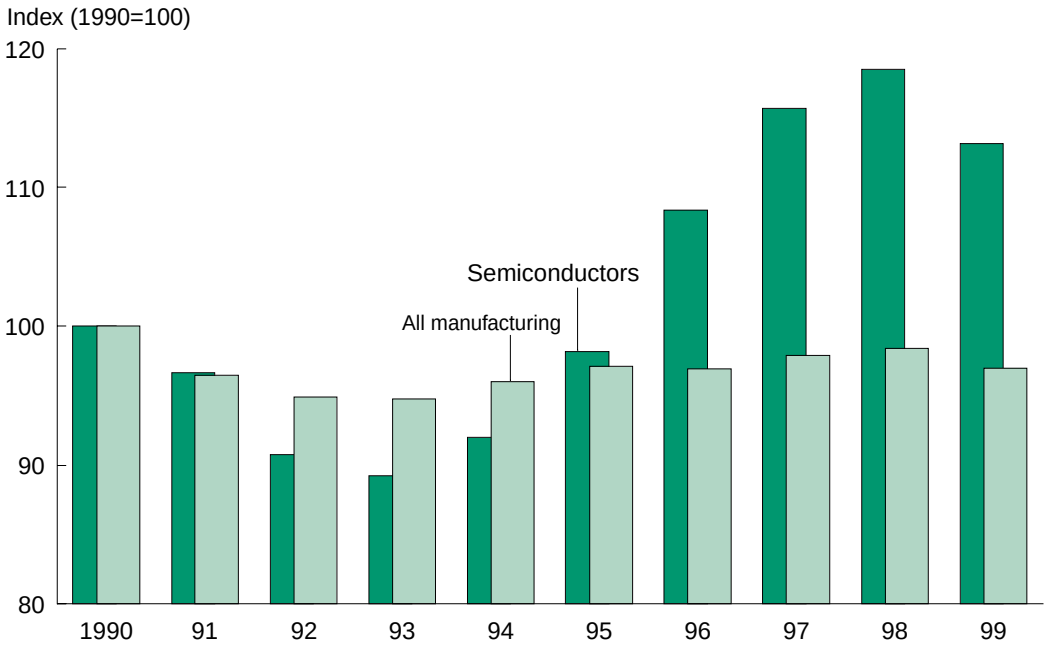
Industry Shipments More Than Doubled Between 1992 and 1997

The 1997 Economic Census reports 980 companies operating 1,082 establishments in the North American Industrial Classification (NAICS) category 334413, "Semiconductors and Related Devices" (table 1). Comparison with the 1992 Economic Census shows that the industry added 157 companies and 160 establishments between 1992 and 1997. (NAICS category 334413 is equivalent to the Standard Industrial Classification (SIC) cate-

Figure 1

Employment growth in semiconductor and all manufacturing industries, 1990-99

Employment in semiconductor manufacturing grew rapidly during the mid-1990's



Source: ERS analysis of Bureau of Labor Statistics data.

Table 1

Production and employment in the U.S. semiconductor industry, 1992-97

All measures indicate rapid growth in the semiconductor industry

Item	Unit	1992	1997	Percent change
Companies	Number	823	980	19.1
Establishments	Number	922	1,082	17.4
Value of shipments	Billion dollars	33.2	78.0	135.1
Cost of materials	Billion dollars	9.8	15.0	52.0
Value added	Billion dollars	23.3	63.7	173.6
Capital expenditures	Billion dollars	3.1	10.5	237.5
Employment	Number	172,200	198,119	15.1
Production workers	Number	84,800	105,781	24.7
Payroll	Million dollars	6,893	9,994	45.0
Benefits	Million dollars	1,564	2,250	43.9
Value added per worker	Dollars	135,290	321,760	137.8
Earnings per worker	Dollars	40,030	50,450	26.0
Benefits per worker	Dollars	9,080	11,360	25.0
Production worker hourly wage	Dollars	13.54	16.36	20.8
Capital expenditures per worker	Dollars	18,121	53,165	99.3

Note: Data are for NAICS sector 334413 for 1997 and SIC 3674 for 1992. Not adjusted for inflation.
Source: ERS analysis of U.S. Bureau of the Census, Economic Census.

gory 3674 used in previous economic censuses, facilitating easy comparison with previous years.) Employment rose by 25,919 jobs, a 15-percent increase. However, these increases appear to understate the actual growth of the industry. The number of production workers (those actually involved in production operations, excluding most administrative, management, and research personnel) and the number of hours each increased about 25 percent. Even more rapid growth in the value of industry shipments indicates that production grew even faster than labor input. The value of industry shipments rose a staggering 135 percent during 1992-97, reaching $78 billion in 1997. This figure is not adjusted for inflation—semiconductor prices actually fell in price. The rapid growth in value added suggests that worker productivity increased considerably.

The value of shipments may overstate the physical product turned out by the industry because the value is double-counted when intermediate products produced by one establishment are sold to another establishment within the same industry to manufacture a final product. The Economic Census reports value added, a measure of output that avoids the double-counting problem. Value added is the difference between the value of product shipments and the cost of materials, supplies, containers, fuel, purchased electricity, and contract work. In 1997, the semiconductors industry purchased materials and supplies valued at nearly $15 billion, and produced value added of $63.75 billion. The value of materials purchases grew by only 52 percent between 1992 and 1997, much slower than the 135 percent growth in value of product shipments. This means that value added grew even faster than shipments—174 percent—between 1992 and 1997.

Growth in Worker Productivity and Wages

Value added per worker, a common measure of worker productivity, was $321,760 for the semiconductor industry in 1997 (table 1). This value is considerably higher than for other industries. In related electronic components industries (such as circuit boards, capacitors, electron tubes) value added per worker ranged between $50,000 and $100,000. The total for all manufacturing was not available at the time of writing, but the 1996 estimate from the Census Bureau's Annual Survey of Manufactures was $93,737. Since semiconductor industry value added grew faster than the number of workers between 1992 and 1997, productivity (as measured by value added per worker) also grew rapidly. Value added per worker grew by $186,000 in the 5 years from 1992 to 1997, an increase of 138 percent.

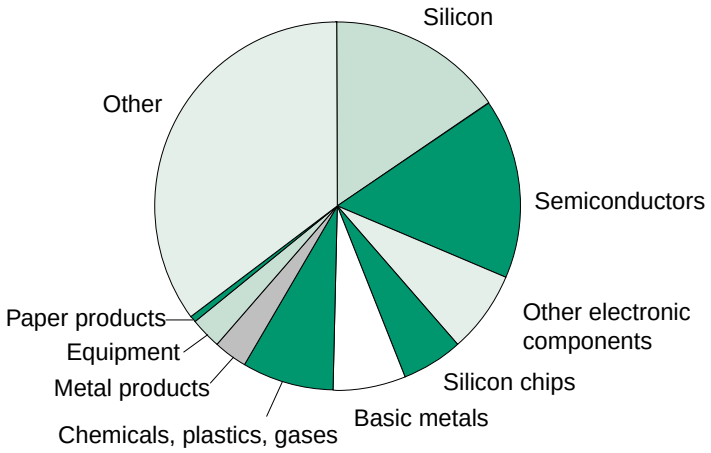
Increases in wages are usually linked to growth in worker productivity. As the value of output produced by a worker increases, companies are willing to pay workers more. The Economic Census data show that wages grew rapidly in the semiconductor industry, but growth in wages absorbed only a small share of the increase in productivity. Wages and salaries per worker rose from $40,030 to $50,450 between 1992 and 1997, an increase of 26 percent. The general level of inflation was 12.7 percent over the period, so this represents an increase in real wages. Nonwage benefits rose at a similar rate of 25 percent, from $9,080 to $11,360 per worker. However, earnings for production-line workers grew more slowly. Average hourly wages for semiconductor production workers grew 20.8 percent from $13.54 to $16.56. While growth in wages did not keep up with growth in value added in the semiconductor industry, the growth in both wages and employment experienced by the industry stands in contrast to the generally stagnant picture in most U.S. manufacturing industries. Wages in the semiconductor industry were significantly higher and grew faster than wages in other manufacturing industries. Earnings per worker for all manufacturing were $33,770 in 1997, $16,230 less than the average for the semiconductor industry. Average wages for all manufacturing rose only 10 percent between 1992 and 1997, less than half the 26-percent increase in the semiconductor industry. In addition, total manufacturing employment fell by 6.9 percent between 1992 and 1997.

Another indicator of the semiconductor industry's rapid growth is its high level of capital expenditures. The industry made an average of $53,000 in capital expenditures for every employee in 1997. This is a very high rate of investment per worker. In 1996, capital expenditures for all manufacturing were less than $7,500 per worker (the data for 1997 were not available when this article was written), so clearly the semiconductor industry was expanding capacity more rapidly than other manufacturing sectors were. The high investment of capital per worker is consistent with the high and increasing productivity indicated by the value added per worker figures. Total capital expenditures in 1997 were $10.5 billion, including $1.9 billion spent on buildings and facilities, and $8.6 billion spent on machinery and equipment. The industry's assets were valued at $59.57 billion at the end of 1997, over $300,000 per worker.

A Variety of Raw Materials Are Purchased

The Economic Census provides detailed information on the range of products made and the materials consumed by each industry. Materials purchases can help analysts evaluate the backward linkages to suppliers in a particular industry. Knowledge of what materials are purchased by manufacturers is helpful in determining whether a community has adequate access to suppliers to attract a plant in a given industry. It is also useful for estimating local economic impacts of manufacturing plants. The census lists 35 types of materials, components, equipment, and parts that are consumed by manufacturers in the semiconductor industry. They are summarized in 10 categories shown in figure 2. The largest single categories of materials are hyperpure silicon (the basic raw material for semiconductors) and semiconductors themselves, each of which had purchases of $1.5 billion in 1997. (Semiconductors are purchased as intermediate products to be used in the manufacture of semiconductor-based microprocessors, integrated circuits, and other products.) Other expenditures are for a variety of raw materials, including basic metals and alloys, plastics, chemicals, and gases, fabricated metal products, computing, communications, optical equipment, instruments, and a large "other materials" category, for which materials were not specified. Expenditures for many materials increased rapidly between 1992 and 1997, indicating that growth in semiconductor production benefited many supplying industries. Expenditures on silicon more than doubled from $675 million to $1.5 billion, and purchases of bolts, nuts, screws, washers, and rivets rose from $3 million to $16.7 million between 1992 and 1997. Other expenses collected by the Economic Census include quantity of electricity consumed, expenditures on electricity, purchased services, and rental payments.

Figure 2
Semiconductor industry purchases of materials, 1992
Semiconductor manufacturers purchase a variety of raw materials



Source: ERS analysis of U.S. Bureau of the Census, 1997 Economic Census.

Semiconductor Manufacturing Is Geographically Concentrated

Semiconductor manufacturers are desirable targets of industry recruiters because they are a growing industry, pay high wages, and employ a relatively educated labor force. While Economic Census data paint a picture of a rapidly growing industry, the prospects of recruiting semiconductor plants for rural communities appear discouraging.

The semiconductor industry is geographically concentrated in the West, Southwest, and Northeast. The two dominant States, California (27.6 percent) and Texas (28.7 percent), had a combined share of 46 percent of semiconductor jobs in 1997 (table 2). However, their share of industry value added was smaller, at 35.3 percent. Arizona, with only one-third as many semiconductor workers as California, recorded value added of $9.7 billion, only 12 percent less than California's total. Oregon and Washington also had shares of value added much greater than their share of employment.

California and Texas received the largest share of semiconductor capital expenditures, but the ratio of capital expenditures to workers suggests that capacity is expanding rapidly in other States. On average, the semiconductor industry made about $53,000 in capital expenditures per worker. In Oregon and Washington, investment was far higher, at $143,500 and $117,000 per worker, respectively. Investment in Arizona and Florida was also above the average, at $74,000 and $65,000 per worker. Texas, Colorado, and Minnesota each had capital expenditures of between $50,000 and $60,000 per worker. All other States had expenditures below $50,000 per worker, including California, at $44,800.

The semiconductor industry is heavily urbanized. According to the Census Bureau's *County Business Patterns* data, only 62 out of 940 semiconductor manufacturing establishments were in nonmetro areas. (Economic Census data on establishments by county had not yet been released when this article was written.) Three-fourths (682) of semiconductor manufacturing establishments were located in large metropolitan areas with population of 1 million or more. Another 15.6 percent of establishments were in metro areas with populations of 500,000 to 1 million, and only 26 establishments were in small metro areas.

In 1995, 50 nonmetro counties had semiconductor establishments, with estimated employment totaling nearly 8,000 jobs (5 percent of the industry total). Nonmetro establishments were scattered across the country, but were largely concentrated in the West,

Table 2

Semiconductor employment, value added, and capital expenditures by State, 1997

California and Texas are the leading employers in the semiconductor industry, but several other States had higher levels of capital investment per worker

State[1]	Employment	Value added	Capital expenditures	Capital expenditures per worker
	Number	Million dollars		Thousand dollars
California	54,597	10,969.1	2,446.4	44.8
Texas	37,088	11,549.2	2,110.9	56.9
Arizona	18,070	9,701.8	1,346.4	74.5
Massachusetts	9,387	1,358.5	261.1	27.8
Oregon	8,309	7,075.8	1,192.6	143.5
Pennsylvania	7,916	3,514.5	230.4	29.1
New York	7,830	625.6	98.7	12.6
Colorado	4,953	1,093.8	258.7	52.2
Florida	3,452	513.6	224.3	65.0
Washington	3,104	350.3	363.5	117.1
Minnesota	2,036	264.7	106.1	52.1
New Jersey	1,934	241.1	74.4	38.4
Ohio	1,932	278.5	35.2	18.2
North Carolina	1,796	166.9	81.9	45.6
New Hampshire	1,450	209.8	57.4	39.6
Connecticut	629	91.9	11.1	17.6
Utah	613	8.5	6.6	10.7
Maryland	594	42.8	18.1	30.4
Wisconsin	519	34.1	1.7	3.2
Illinois	407	38.8	9.6	23.6
Michigan	331	21.2	5.6	16.9
Other States	31,172	15,596.7	1,592.3	51.1
Total	198,119	63,747.2	10,532.9	53.2

[1]States with less than 100 employees and those for which operations of individual firms might be disclosed are not shown.
Source: Calculated by ERS from U.S. Bureau of the Census, 1997 Economic Census data.

Northeast, and Midwest (fig. 3). Pennsylvania had the most nonmetro semiconductor establishments (seven), followed by Iowa (six). However, most of these establishments were very small. The three Oregon establishments accounted for about half of nonmetro employment in semiconductors.

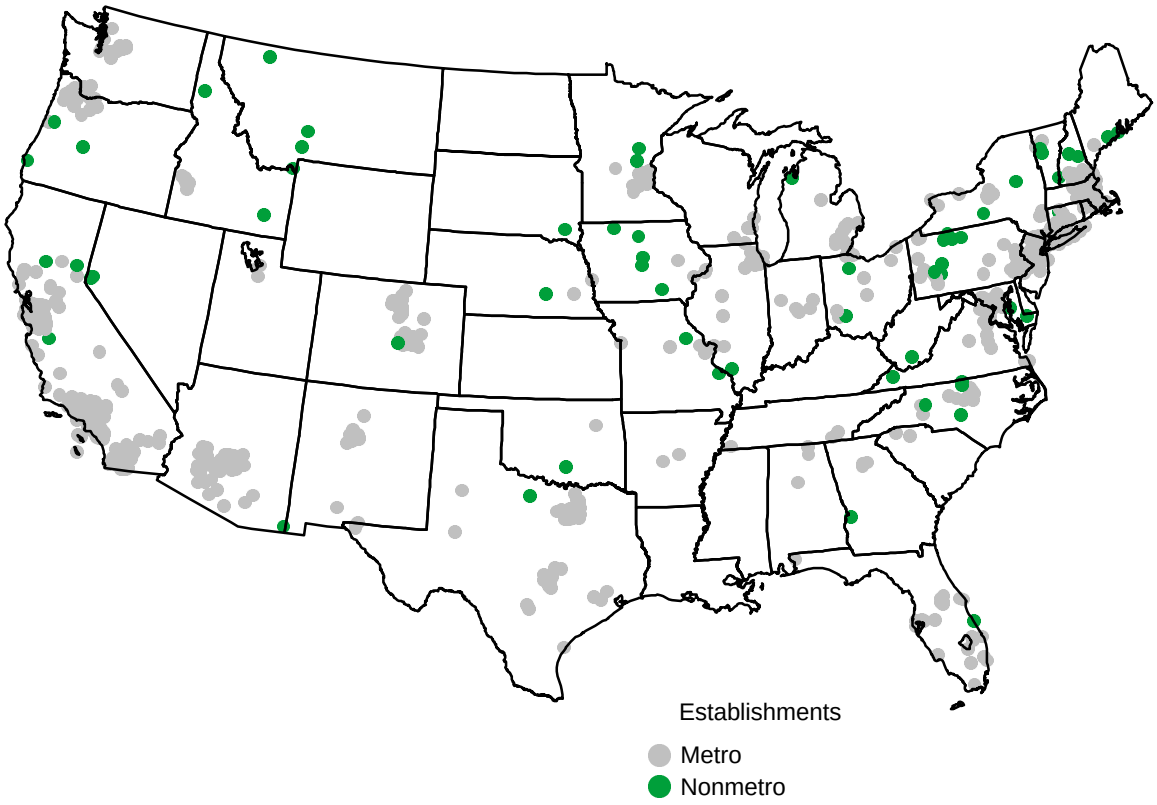
Rural Locations May Become More Attractive

The semiconductor industry appears to be on the upswing of the "product cycle." According to the product cycle theory, new, innovative industries tend to prefer urban locations where they have access to new ideas, knowledge, and innovation. The geographic concentration of semiconductor establishments seems to be in line with this theory. However, the product cycle suggests that rural locations may become more attractive. As the semiconductor industry matures, it may become more conscious of costs and less concerned about innovation, making rural areas with lower land and facilities costs more attractive. A couple of other factors may brighten prospects for rural areas to gain a greater share of this industry. Advances in telecommunications improve access to information in rural areas, and natural amenities of rural areas may be particularly attractive to environmentally conscious managers and employees in this industry. However, rural areas also must compete with overseas locations in Asia and other regions where labor costs are often lower and environmental and other regulations can be less stringent. *[Fred Gale, 202-694-5349, fgale@ers.usda.gov]*

Figure 3

Metro and nonmetro semiconductor establishments, 1995

Semiconductor manufacturers are geographically concentrated in the West, Northeast, Midwest, and parts of Texas and Florida



Source: Calculated by ERS from U.S. Bureau of the Census, *1995 County Business Patterns* data.